

## Deriving sub-Hertz data streams from Q330 1Hz output

This is a proposal to specify a standardized method of generating filtered and decimated data streams whose source is one of the 1Hz outputs from the Q330. These outputs not only include 1Hz data from the main digitizer, but some SOH information, such as clock quality or Auxiliary A/D results.

The goal is to align samples of decimated streams at  $1/\text{samplerate}$ . For instance, samples for 0.1hz data should occur at a multiple of 10 seconds, and 0.01hz data should occur at a multiple of 100 seconds. Currently, Quanterra DPs (such as Socorro and Baler14) just starting filling the FIR filters for these decimated streams with the first 1Hz data they get from the Q330. The examples shown are from Socorro, and of course, other DPs may use very different methods of decimation.

There are actually two changes made:

1. Synchronize filling the FIR filter so that the output samples arrive at a consistent time, regardless of when the DP first acquires data from the Q330.
2. For the case of linear phase filters throughout the filter chain, align samples to  $1/\text{samplerate}$ . We add two new filters for this.

In Socorro the first change determines whether a data stream has, as it's data source, a 1Hz stream. If it does, then a flag is set "slipping" and the  $1/\text{samplerate}$  value "slip\_modulus" is calculated. From the LCQ setup code:

```

else if raw_data_source = READ_PREV_STREAM
  then
    begin
      if prev_link^.rate > 0
        then
          input_sample_rate := prev_link^.rate
        else
          input_sample_rate := 1.0 / abs(prev_link^.rate) ;
      if source_fir <> NIL
        then
          delay := prev_link^.delay + source_fir^.dly / input_sample_rate
        else
          delay := prev_link^.delay ;
      charging := TRUE ;
----- Added Code -----
      { see if root source is 1hz }
      p := prev_link ;
      while p^.prev_link <> NIL do
        p := p^.prev_link ;
      if (p <> NIL) and (p^.rate = 1)
        then
          begin
            { yes, need to synchronize based on rate }
            slipping := TRUE ;
            slip_modulus := abs(rate) ; { .1hz has modulus of 10 }
          end
-----
    end

```

For those DP's (such as Socorro and Baler) that maintain continuity between execution, the "slipping" status needs to be stored as well. This avoids having to re-synchronize, and thereby introduce a data gap, when synchronization had already been achieved before, as the FIR filter values are already in the continuity file.

The “slipping” variable can be thought of as a clutch, or a switch, not letting data into the fir filter until the appropriate time. In Socorro, at the beginning of processing new data for a LCQ:

```

if slipping
then
begin { for derived, see if reached modulus }
int_time := round((src_samp - 1) * input_sample_rate + data_timetag) ;
if int_time mod slip_modulus = slip_modulus - 1
then
slipping := FALSE
else
exit { throw data away }
end ;

```

“int\_time” is essentially the timetag (in seconds since 2000) for the 1Hz sample from the Q330, ignoring filter delays.

The second change involves using filters with a delay that, when added to the 15 second delay already present in the 1Hz main digitizer, results in having the decimated samples be generated at a multiple of 1/samplerate. Note that these filters work assuming that your DP uses the same convention that Socorro uses. When Socorro builds a FIR filter for a LCQ (assuming no continuity is available) it sets the “count” of the number of samples in the FIR filter to the length of the filter minus 1. This results in an output sample for the first input sample.

For converting from 1Hz to 0.1Hz (for example, LHZ to VHZ) the new filter “VLP389” is used instead of the standard “DEC10”. Using the standard Quanterra FIR filter specification format, this filter is:

```

VLP389 name of filter
389 number of points in this filter
1.0 digital gain
10 decimation factor DELAY=194
1.552566394584E-08 3.838396805256E-08 8.362779588160E-08 1.611856650765E-07 2.855294744823E-07
4.745457226814E-07 7.493373613481E-07 1.133592677088E-06 1.652402275925E-06 2.330427428518E-06
3.189336982250E-06 4.244466110163E-06 5.500718985138E-06 6.947785187742E-06 8.554818995995E-06
1.026484432301E-05 1.198920679926E-05 1.360249119436E-05 1.493842691710E-05 1.578731698718E-05
1.589559564507E-05 1.496809882671E-05 1.267355442171E-05 8.653767865499E-06 2.536720154462E-06
-6.046302489149E-06 -1.743978324789E-05 -3.193970873875E-05 -4.976679353047E-05 -7.103832499508E-05
-9.574009270878E-05 -1.237001281373E-04 -1.545662057863E-04 -1.877891685389E-04 -2.226141463211E-04
-2.580816070830E-04 -2.930398897929E-04 -3.261704417989E-04 -3.560263903179E-04 -3.810843492955E-04
-3.998085424451E-04 -4.107254096236E-04 -4.125059559304E-04 -4.040522153346E-04 -3.845834135837E-04
-3.537168195160E-04 -3.115378713577E-04 -2.586540951013E-04 -1.962275488594E-04 -1.259811477109E-04
-5.017518265277E-05 2.844831201260E-05 1.067540572146E-04 1.813337070203E-04 2.486544777587E-04
3.052309010550E-04 3.478123642856E-04 3.735773180385E-04 3.803236007367E-04 3.666434036282E-04
3.320710779809E-04 2.771923601331E-04 2.037047230356E-04 1.144204406806E-04 1.320656090328E-05
-9.514078807411E-05 -2.050866145468E-04 -3.106066344345E-04 -4.054869377349E-04 -4.836605629994E-04
-5.395643227932E-04 -5.684964442834E-04 -5.669537730318E-04 -5.329266106907E-04 -4.661298988553E-04
-3.681514720867E-04 -2.425015060503E-04 -9.455197026659E-05 6.863931335717E-05 2.386187747019E-04
4.059330165016E-04 5.606150098640E-04 6.927381973863E-04 7.930101501160E-04 8.533727144001E-04
8.675725693010E-04 8.316651094423E-04 7.444158080483E-04 6.075667962541E-04 4.259422734851E-04
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-1.138503279404E-03 -9.421560123941E-04 -6.770305674248E-04 -3.548035850963E-04 8.629525406917E-06
3.938522550447E-04 7.788870544391E-04 1.140375685799E-03 1.454921250676E-03 1.700519338554E-03
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5.405199843135E-05 8.758642868356E-04 1.692298775680E-03 2.452799616041E-03 3.107213842280E-03
3.608895501699E-03 3.917779673295E-03 4.003236312754E-03 3.846516408026E-03 3.442617091426E-03
2.801417900821E-03 1.947976354023E-03 9.219157645641E-04 -2.241104816572E-04 -1.426838923738E-03
-2.615605374573E-03 -3.716195765456E-03 -4.655143758048E-03 -5.364242712043E-03 -5.785013832068E-03
-5.872860607418E-03 -5.600643400193E-03 -4.961427762851E-03 -3.970195379824E-03 -2.664356080425E-03
-1.102960913674E-03 6.354132582377E-04 2.456061522632E-03 4.252708231777E-03 5.913027807411E-03
7.324867533633E-03 8.382857359878E-03 8.995055809435E-03 9.089245553003E-03 8.618548933728E-03
7.565943496045E-03 5.947439964943E-03 3.813634534079E-03 1.249480992454E-03 -1.627797630402E-03
-4.672638210191E-03 -7.716787115331E-03 -1.057645210709E-02 -1.306064905261E-02 -1.498036021034E-02
-1.615806333373E-02 -1.643715526114E-02 -1.569078258614E-02 -1.382960671136E-02 -1.080807094477E-02
-6.628801743854E-03 -1.344861825153E-03 4.940324525219E-03 1.207543915120E-02 1.986607558565E-02
2.808170739344E-02 3.646453116726E-02 4.473979600604E-02 5.262714980923E-02 5.985247435163E-02
6.615964924099E-02 7.132168148082E-02 7.515066291015E-02 7.750607115759E-02 7.830100830038E-02
7.750607115759E-02 7.515066291015E-02 7.132168148082E-02 6.615964924099E-02 5.985247435163E-02
5.262714980923E-02 4.473979600604E-02 3.646453116726E-02 2.808170739344E-02 1.986607558565E-02

```

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-1.306064905261E-02	-1.057645210709E-02	-7.716787115331E-03	-4.672638210191E-03	-1.627797630402E-03
1.249480992454E-03	3.813634534079E-03	5.947439964943E-03	7.565943496045E-03	8.618548933728E-03
9.08924553003E-03	8.995053809435E-03	8.38285389878E-03	7.324887533633E-03	5.913027807411E-03
4.252708231777E-03	2.456061522632E-03	6.354132582377E-04	-1.102960913674E-03	-2.664356080425E-03
-3.970195379824E-03	-4.961427762851E-03	-5.600643400193E-03	-5.872860607418E-03	-5.785013832068E-03
-5.364242712043E-03	-4.655143758048E-03	-3.716195765456E-03	-2.615605374573E-03	-1.426838923738E-03
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-1.418870913453E-03	-1.991724770718E-03	-2.417269551530E-03	-2.679118119865E-03	-2.771301493786E-03
-2.698023247754E-03	-2.472836888205E-03	-2.117326771743E-03	-1.659397590689E-03	-1.131294383117E-03
-5.674838557405E-04	-2.528464426306E-06	5.309224020114E-04	1.003913787737E-03	1.392648421779E-03
1.679565073285E-03	1.853991651826E-03	1.912359959705E-03	1.857995436810E-03	1.700519338554E-03
1.454921250676E-03	1.140375685799E-03	7.788870544391E-04	3.938522550447E-04	8.629525406917E-06
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-1.301425007313E-03	-1.267989808042E-03	-1.165179186662E-03	-1.002993788038E-03	-7.941831891721E-04
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1.813337070203E-04	1.067540572146E-04	2.844831201260E-05	-5.017518265277E-05	-1.259811477109E-04
-1.962275488594E-04	-2.586540951013E-04	-3.115378713577E-04	-3.537168195160E-04	-3.845834135837E-04
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-3.560263903179E-04	-3.261704417989E-04	-2.930398897929E-04	-2.580816070830E-04	-2.226141463211E-04
-1.877891685389E-04	-1.545662057863E-04	-1.237001281373E-04	-9.574009270878E-05	-7.103832499508E-05
-4.976679353047E-05	-3.193970873875E-05	-1.743978324789E-05	-6.046302489149E-06	2.536720154462E-06
6.653767865499E-06	1.267355442171E-05	1.496809882761E-05	1.589559564507E-05	1.578731698718E-05
1.493842691710E-05	1.360249119436E-05	1.198920679926E-05	1.026484432301E-05	8.554818995995E-06
6.947785187742E-06	5.500718985138E-06	4.244466110163E-06	3.189336982250E-06	2.330427428518E-06
1.652402275925E-06	1.133592677088E-06	7.493373613481E-07	4.745457226814E-07	2.855294744823E-07
1.611856650765E-07	8.362779588160E-08	3.838396805256E-08	1.552566394584E-08	

For decimating from 0.1Hz to 0.01Hz (for example, from VHZ to UHZ) the new filter "ULP379" is used instead of the standard "DEC10" :

ULP379 name of filter

379 number of points in this filter

1.0 digital gain

10 decimation factor DELAY=189

1.026451784988E-08	1.180827438263E-08	1.222270072841E-08	1.784569043697E-09	-3.171089438061E-08
-1.077291467270E-07	-2.554953559066E-07	-5.168406471238E-07	-9.492918609426E-07	-1.629243835370E-06
-2.654991487515E-06	-4.149339231814E-06	-6.261453784789E-06	-9.167581524892E-06	-1.30702327112E-05
-1.819535922437E-05	-2.478735261764E-05	-3.310122477396E-05	-4.339209432774E-05	-5.590172080761E-05
-7.084228458081E-05	-8.837774901527E-05	-1.086033867683E-04	-1.315243117997E-04	-1.570341146662E-04
-1.848949188490E-04	-2.147203583052E-04	-2.459631087719E-04	-2.779086352362E-04	-3.096767386907E-04
-3.402323135044E-04	-3.684064187493E-04	-3.929283049387E-04	-4.124684933983E-04	-4.256923594327E-04
-4.313229018453E-04	-4.282106262745E-04	-4.154077269900E-04	-3.922429908564E-04	-3.583933008473E-04
-3.139471951601E-04	-2.594556781198E-04	-1.959656613106E-04	-1.250316495320E-04	-4.870211218377E-05
3.052211243450E-05	1.097586447595E-04	1.858433664932E-04	2.554571595010E-04	3.152757039169E-04
3.621366034745E-04	3.932163833021E-04	4.062084327728E-04	3.994918660218E-04	3.722806580722E-04
3.247423843257E-04	2.580765172940E-04	1.745435403532E-04	7.743812787763E-05	-2.899773516609E-05
-1.397226672272E-04	-2.491022698159E-04	-3.511676454733E-04	-4.399159776456E-04	-5.096395949121E-04
-5.552669179358E-04	-5.726963932934E-04	-5.591031729212E-04	-5.131980615309E-04	-4.354192598725E-04
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4.527235473365E-04	5.995334002354E-04	7.211790815244E-04	8.089187416563E-04	8.55386106716E-04
8.551118755616E-04	8.050086636132E-04	7.046986521457E-04	5.567417551315E-04	3.666884759904E-04
1.429595323193E-04	-1.034559890014E-04	-3.594789754338E-04	-6.105789107604E-04	-8.415454811974E-04
-1.037355654481E-03	-1.184090091542E-03	-1.269846355483E-03	-1.285592795306E-03	-1.225906639409E-03
-1.089542985518E-03	-8.797880768168E-04	-6.045603413930E-04	-2.762357484243E-04	8.881051943921E-05
4.709370574344E-04	8.482172520524E-04	1.197624514067E-03	1.496362338092E-03	1.723266866410E-03
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9.177999012550E-03	4.378127047711E-04	-9.727724235811E-05	-6.582855701364E-04	-1.212663227346E-03
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1.629414948190E-04	9.797026440298E-04	1.784813789684E-03	2.528273803602E-03	3.160839294628E-03
3.670807254466E-03	3.918388793951E-03	3.975744765012E-03	3.792072035007E-03	3.364001152506E-03
2.702906508667E-03	1.835108966987E-03	8.011831689895E-04	-3.456411119405E-04	-1.541940144637E-03
-2.717322124106E-03	-3.798268482339E-03	-4.712396050860E-03	-5.392909415564E-03	-5.782988553657E-03
-5.839846472553E-03	-5.538196386724E-03	-4.872888431900E-03	-3.860511584446E-03	-2.539805943971E-03

-9.707916038829E-04	7.674100682562E-04	2.580012466451E-03	4.361131629765E-03	5.999288918806E-03
7.383587747446E-03	8.410251879376E-03	8.989176473957E-03	9.050124884710E-03	8.548205984557E-03
7.468289206184E-03	5.828057093995E-03	3.679456341875E-03	1.108385277773E-03	-1.767455172892E-03
-4.802523432728E-03	-7.829089530977E-03	-1.066435913962E-02	-1.311876335018E-02	-1.500503421626E-02
-1.614763018295E-02	-1.639204126750E-02	-1.561349373078E-02	-1.372458920009E-02	-1.068145360293E-02
-6.488035284000E-03	-1.198276407116E-03	5.084016923480E-03	1.220766753683E-02	1.997892624731E-02
2.816840227991E-02	3.651983914056E-02	4.476035176393E-02	5.261166083662E-02	5.980180304551E-02
6.607676494603E-02	7.121148510555E-02	7.501969457590E-02	7.736211848923E-02	7.815263905001E-02
7.736211848923E-02	7.501969457590E-02	7.121148510555E-02	6.607676494603E-02	5.980180304551E-02
5.261166083662E-02	4.476035176393E-02	3.651983914056E-02	2.816840227991E-02	1.997892624731E-02
1.220766753683E-02	5.084016923480E-03	-1.198276407116E-03	-6.488035284000E-03	-1.068145360293E-02
-1.372458920009E-02	-1.561349373078E-02	-1.639204126750E-02	-1.614763018295E-02	-1.500503421626E-02
-1.311876335018E-02	-1.066435913962E-02	-7.829089530977E-03	-4.802523432728E-03	-1.068145360293E-03
1.108385277773E-03	3.679456341875E-03	5.828057093995E-03	7.468289206184E-03	8.548205984557E-03
9.050124884710E-03	8.989176473957E-03	8.410251879376E-03	7.383587747446E-03	5.999288918806E-03
4.361131629765E-03	2.580012466451E-03	7.674100682562E-04	-9.707916038829E-04	-2.539805943971E-03
-3.828057093995E-03	-4.712396050860E-03	-5.839846472553E-03	-5.839846472553E-03	-5.980180304551E-03
-5.392909415564E-03	-4.712396050860E-03	-3.798268482339E-03	-2.717322124106E-03	-1.541940144637E-03
-3.456411119405E-04	8.011831689895E-04	1.835108966987E-03	2.702906508667E-03	3.364001152506E-03
3.792072035007E-03	3.975744765012E-03	3.918388793951E-03	3.637080725446E-03	3.160839294628E-03
2.528273803602E-03	1.784813789684E-03	9.797026440298E-04	1.629414948190E-04	-6.176376947216E-04
-1.319008184603E-03	-1.905157797142E-03	-2.348767885561E-03	-2.632294775655E-03	-2.748424901329E-03
-2.699912806241E-03	-2.498846476193E-03	-2.165415224119E-03	-1.726279974542E-03	-1.212663227346E-03
-6.582855701364E-04	-9.727724235811E-05	4.378127047711E-04	9.177999012550E-04	1.318349511609E-03
1.621093889591E-03	1.814339889434E-03	1.893349127932E-03	1.860200354469E-03	1.723266866410E-03
1.496362338092E-03	1.197624514067E-03	8.482172520524E-04	4.709370574344E-04	8.881051943921E-05
-2.762357484243E-04	-6.045603413930E-04	-8.797880768168E-04	-1.089542985518E-03	-1.225906639409E-03
-1.285592795306E-03	-1.269846355483E-03	-1.184090091542E-03	-1.037355654481E-03	-8.415454811974E-04
-6.105789107604E-04	-3.594789754338E-04	-1.034559890014E-04	1.429595323193E-04	3.666884759904E-04
5.567417551315E-04	7.046986521457E-04	8.050086636132E-04	8.551118755616E-04	8.553836106716E-04
8.089187416563E-04	7.211790815244E-04	5.995334002354E-04	4.527235473565E-04	2.902919216533E-04
1.220050996668E-04	-4.269394694667E-05	-1.951766613779E-04	-3.280397408896E-04	-4.354192598725E-04
-5.131980615309E-04	-5.591031729212E-04	-5.726963932934E-04	-5.552669179358E-04	-5.096395949121E-04
-4.399159776456E-04	-3.511676454733E-04	-2.491022698159E-04	-1.397226672272E-04	-2.899773516609E-05
7.743812787763E-05	1.745435403532E-04	2.580765172940E-04	3.247423843257E-04	3.722806580722E-04
3.994918660218E-04	4.062084327728E-04	3.932163833021E-04	3.621366034745E-04	3.152757039169E-04
2.554571595010E-04	1.858433664932E-04	1.097586447595E-04	3.052211243450E-05	-4.870211218377E-05
-1.250316495320E-04	-1.959656613106E-04	-2.594556781198E-04	-3.139471951601E-04	-3.583933008473E-04
-3.922429908564E-04	-4.154077269900E-04	-4.282106262745E-04	-4.313229018453E-04	-4.256923594327E-04
-4.124684933983E-04	-3.929283049387E-04	-3.684064187493E-04	-3.402323135044E-04	-3.096767386907E-04
-2.779086352362E-04	-2.459631087719E-04	-2.147203583052E-04	-1.848949188490E-04	-1.570341146662E-04
-1.315243117997E-04	-1.086033867683E-04	-8.837774901527E-05	-7.084228458081E-05	-5.590172080761E-05
-4.339209432774E-05	-3.310122477396E-05	-2.478735261764E-05	-1.819535922437E-05	-1.307022327112E-05
-9.167581524892E-06	-6.261453784789E-06	-4.149339231814E-06	-2.654991487515E-06	-1.629243835370E-06
-9.492918609426E-07	-5.168406471238E-07	-2.554953559066E-07	-1.077291467270E-07	-3.171089438061E-08
1.784569043697E-09	1.222270072841E-08	1.180827438263E-08	1.026451784988E-08	

These new filters would replace "DEC10" in the DP Tokens once DPs have been updated to include the new filters.